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WSC E-29



# CATEGORY II TEST REPORT FOR WIND MEASURING SET AN/TMQ-15



AF 19 (626)-16

WEATHER SYSTEM CENTER
United Aircraft
EAST HARTFORD, CONNECTICUT

WSC E-29
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# CATEGORY II TEST REPORT FOR WIND MEASURING SET AN/TMQ-15

Weather Observing and
Forecasting System 433L
(Contract No. AF 19(626)-16)

UNITED AIRCRAFT
CORPORATE SYSTEMS CENTER
Weather System Center

Farmington, Connecticut
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ABSTRACT

This report provides the results of a test program conducted on the Wind Measuring Set, AN/TMQ-15. The program was conducted to meet the objectives of testing as defined in AFR 80-14, and specifically to determine the suitability of the AN/TMQ-15 as a tactical wind measuring set. The test program was conducted separately at two test sites to provide broader coverage of testing.

The conclusion is reached from the test results, that in its present configuration, the AN/TMQ-15 is not suitable for use as a tactical wind measuring set. Recommendations for engineering modifications to provide the ruggedness and flexibility required of tactical equipment are included which, when incorporated, will result in a suitable item.

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Publication Review

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Report No. WSC E-29

Category II Test Report for
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1.1 Category II tests were conducted to determine that the Wind Measuring Set, in an operational environment, meets the Category II objectives as outlined in AFR 80-14. These objectives are required to determine:

a. The electrical and mechanical suitability of the equipment to perform its intended purpose.

b. The extent to which the equipment meets military requirements particularly with respect to tactical utilization.

c. Maintenance problems and supply requirements, including adequacy of AGE.

d. Equipment effectiveness when used under operational conditions in an operational environment.

e. Equipment reliability, availability, and maintainability.

f. Human Factors requirements.

g. Electrical characteristic testing.

## 2. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

### 2.1 Results

Tests on the AN/TMQ-15 were conducted in accordance with WSC E-15, Appendix J, Category I and II Test Plan for Wind Measuring Set, AN/TMQ-15. The results of the test program revealed discrepancies in design, described more fully below, which limit the usefulness of the equipment as a tactical wind measuring set.

### 2.2 Conclusions

2.2.1 The cases are heavy and extremely cumbersome. The case containing the mast assembly is dangerously top heavy when the 1000 feet of connecting cable is stored in its allocated space in the upper section.

2.2.2 The position of the electrical connector at the base of the mast allows the entry of foreign matter into the socket. This creates difficulties in field use.

2.2.3 The corkscrew anchors are nearly impossible to insert into frozen ground.

2.2.4 Orientation of the Direction Sensor is extremely difficult to retain, since the adjustment must be made with the mast collapsed, and there is no provision for retaining alignment when the mast is extended.

2.2.5 When the equipment is transported over rough terrain some adjustments are disturbed and recalibration is necessary before full operation can be achieved.

2.2.6 "Play" between the Wind Direction sensing element and the direction synchro resulted in poor resolution of wind direction readings.

2.2.7 The Wind Direction Vane is insufficiently damped, resulting in excessive overshoot.

2.2.8 The bearing sleeve around the anemometer shaft assembly has a tendency to "ice up", when exposed to freezing precipitation, and consequently inhibit the rotation of the wind speed sensor.

2.2.9 With the wind direction synchro energized, a constant reading is present on the wind speed indicator. This is due to inadequate decoupling of the +12 volt power supply.

2.2.10 The guying system provided for securing the mast is inadequate. The top of the mast sways substantially in gusty winds, thus producing an error in readings.

2.2.11 No provisions have been made for leveling the mast on rough terrain. Tripod legs are not rigid enough.

2.2.12 Fasteners which secure the lid to cases are extremely difficult to snap open without the use of a tool.

## 2.3 Recommendations

2.3.1 The amount of connecting cable stored in the mast assembly case should be limited to 100 feet and this should be located in the bottom of the case. Additional cable should be stored on an external cable reel. Handles should be provided on the lid of the mast assembly carrying case.

2.3.2 The mast connector should be located at least two feet above the mast base and should be provided with a waterproof boot. Provision should be made to coil slack cable outside the mast when it is lowered.

2.3.3 Stakes which may be driven into the ground should be substituted for the screw anchors.

2.3.4 Orientation of the Wind Direction Sensor should be performed when the mast is extended. This could be accomplished by providing the mast with a slot and key arrangement to hold mast sections in alignment. The wind direction sensor transducer case and cross arm should also index in a slot. A hole could be provided, through the mast, which would receive a circular non-magnetic pipe or sighting bar. By sighting along the sighting bar and turning the entire mast assembly, orientation of the sensor could be achieved.

2.3.5 Components requiring adjustment should be ruggedized and more adequate packaging should be provided for protection against vibration encountered in transportation over rough terrain.

2.3.6 The slot and key arrangement between the Wind Direction sensor and synchro should be manufactured to closer tolerance and maximum "play" permitted should not exceed $\pm 0.05^\circ$.

2.3.7 The Wind Direction Vane should be damped by using an eddy current disk or drag cup arrangement.

2.3.8 The problem of freezing of the anemometer shaft bearing sleeve is difficult to solve due to the low internal mass of the Wind Speed Sensor. A slight amount of friction resulting from frozen moisture will add a considerable drag force on the shaft. However, the use of silicon type oil or grease as a regular maintenance procedure would alleviate the problem to some degree.

2.3.9 A low pass filter should be used in the power supply to eliminate the possibility of 400 cycle voltage appearing on the power supply output leads.

2.3.10 A double set of guy wires should be provided to eliminate mast sway.

2.3.11 Tripod legs should be made adjustable in length to provide for leveling assembly in rough terrain. Tripod legs should also be made more rigid. The ends of the tripod legs should be provided with a disk to provide support in loose sand.

2.3.12 Fasteners with a handle for additional leverage should be provided on case lids.

2.3.13 Redesign should be accomplished to provide accessible test points, more orderly internal layout of cabling and conductors and to provide better access to components to meet maintenance requirements. Proper identification of wires and terminals should be provided.

## 3. INTRODUCTION

### 3.1 Scope

This report presents the results of Category II tests of the Wind Measuring Set, AN/TMQ-15. These tests were performed at Westover Air Force Base, Chicopee Falls, Mass.; L. G. Hanscom Field, Bedford, Mass.; and the United Aircraft Corporation Pilot Wind Tunnel, East Hartford, Conn. These tests were conducted in accordance with report number WSC E-15, Appendix J, Category I and II Test Plan for Wind Measuring Set, AN/TMQ-15.

### 3.2 Test Schedule

Prior to field testing the AN/TMQ-15 was calibrated in the UAC Research Laboratory Pilot Wind Tunnel. Tests were conducted on Sept. 27, 1962 and Oct. 10, 1962. Field testing conducted at Westover AFB and Hanscom Field started on October 10, 1962 and lasted until February 15, 1963.

### 3.3 Test Objectives

3.3.1 Category II tests were conducted to determine whether the AN/TMQ-15, in an operational environment, meets the Category II test objectives as expressed in AFR 80-14. These objectives include:

3.3.1.1 The electrical and mechanical capability of the equipment to meet its intended purpose.

3.3.1.2 The extent to which the equipment meets military requirements.

3.3.1.3 Maintenance problems and supply requirements including adequacy of AGE.

3.3.1.4 Effectiveness when used in an operational environment under operational conditions.

3.3.1.5 Equipment reliability, availability, and maintainability.

3.3.1.6 Human factors requirements.

3.3.1.7 Electrical characteristics.

### 3.4 Test Authorization

The Category II tests of the Wind Measuring Set, AN/TMQ-15, were carried out in partial fulfillment of section 3.4.2 of the 433L System Program authorized by Government Contract No. AF 19(626)-16. Specific cognizance of this program is vested in the 433L System Program Office (SPO), 424 Trapelo Road, Waltham 54, Mass.

## 4. DESCRIPTION OF TEST ITEM

### 4.1 System Description

4.1.1 The Wind Measuring Set, AN/TMQ-15 is a portable, lightweight, transistorized equipment used to measure and transmit wind speed and direction from sensing elements to a remote indicator. The equipment consists of two elements; the wind speed and wind direction sensors mounted on a cross arm of a mast, and a translator and power supply unit. The system is powered by self-contained batteries and/or 115 volt 50/60 cycle line. The stated SOR requirement is that the sensors may be placed up to 10,000 feet from the translator-power supply unit, and will operate up to five readouts through field telephone wire, with no requirement for additional amplifiers or degradation of accuracy.

4.1.2 The Wind Measuring Set is composed of the following components:

4.1.2.1 Wind Speed Transmitter

The Wind Speed Transmitter senses wind speed by means of an inertialess transducer driven by a lightweight, reinforced plastic, three-cup anemometer. The transducer consists of a perforated disc which alternately masks and exposes a photo-transistor to an incandescent lamp; thus, the rotation of the anemometer is sensed without imposing frictional drag on the movement of the anemometer.

4.1.2.1.1 The photo-transistor produces a pulse-type signal which is fed to an amplifier contained in the transmitter housing. This pulse signal is then transmitted to the translator and converted to a DC analog current proportional to wind speed.

4.1.2.1.2 The amplifier unit in the transmitter housing is of solid-state circuitry. It processes the signal from the photo-transistor and transmits it, by means of a cable, to the translator unit.

4.1.2.1.3 The perforated disc, photo-transistor, light source, and amplifier is contained in a weatherproof housing approximately 3 inches in diameter and 8 inches in length. The height of the over-all unit (anemometer, housing, and rod for mounting the unit on the crossarm) does not exceed 16 inches.

4.1.2.1.4 The following are the wind speed transmitter operating specifications:

| | |
|---|---|
| Ranges | 0 to 25 and 0 to 100 knots |
| Threshold Speed | 0.75 knots |
| Accuracy | ± 1.0% of true speed or 0.15 knots, whichever is greater |
| Wind Speed Distance Constant | Approximately 5 feet |
| Power Required | 10.6 to 12.6 VDC, 40 ma. max. current |
| Transmitter Output | Pulse amplitude: 0.5 millivolts into 600 ohms. |

4.1.2.2 Wind Direction Transmitter

4.1.2.2.1 The Wind Direction Transmitter senses wind direction by means of a lightweight, counterbalanced plastic vane, coupled to an AC selsyn transmitter. A means is provided for aligning this sensor to a base direction.

4.1.2.2.2 The AC selsyn transmitter senses changes in direction. These changes are transmitted by cable to the Translator unit.

4.1.2.2.3 The length of the wind vane, including the counterbalance, is approximately 13.0 inches. The diameter of the transmitter housing is approximately 3 inches; the over-all length of the transmitter, including the vane, is less than 19.0 inches.

4.1.2.2.4 The following are the Wind Direction Transmitter operating specifications:

| | |
|---|---|
| Mechanical Range | Full $360^\circ$ range |
| Electrical Range | $357^\circ$ minimum |
| Accuracy | $\pm 3.0^\circ$ |
| Threshold of Operation | 0.75 knots |
| Response | Damping ratio of .3 with less than 30% overshoot[1] |
| Power | 10.6 to 12.6 VDC, 100 milliamperes maximum current |
| Transmitter Output | 3 line signal to operate an AC selsyn |

4.1.2.3 Translator and Power Supply Unit

4.1.2.3.1 The translator and power supply unit produces the regulated power required by the wind sensing instruments and, in return, receives their output signals. This unit processes these signals so that they will be suitable for presentation to the system's indicators and/or recorders. The unit employs solid-state circuitry throughout and is powered by 115 volt 50/60 cycle per second line power and/or self-contained batteries.

4.1.2.3.2 Although recorders will not be a part of the packaged set, a recorder outlet is provided on the Translator Unit.

[1] Damping ratio of .3 is defined as: $\frac{2\pi h}{\sqrt{1-h^2}} = \log \frac{x1}{x2}$

Where h = damping ratio; x1, x2 are successive amplitudes of the decay curve on the same side of the final deflection.

4.1.2.3.3 Control of the entire system is centered in the Translator Unit. The front panel contains the necessary calibrating controls, an on-off switch, indicating meters for wind direction (in tens of degrees) and wind speed (in knots), and a range selector switch by means of which the full-scale range of the system can be chosen to fit the prevailing conditions. Two ranges are offered by the latter switch: 0 to 25 and 0 to 100 knots.

4.1.2.3.4 The following are the translator-power supply operating specifications:

Ranges:

| | |
|---|---|
| Wind Speed | Two selectable ranges, 0 to 25 and 0 to 100 knots |
| Wind Direction | $0^\circ$ to $360^\circ$ |

Accuracy:

| | |
|---|---|
| Wind Speed | ± 1.0% |
| Wind Direction | ± $3.0^\circ$ (translator and transmitter errors taken together) |
| Power | 12 VDC battery pack or 115 volt 50/60 cps AC |
| Dimensions | Approximately 8 x 16 x 12 inches |

## 5. TESTS PERFORMED

All Category II tests required under Annex B of the test plan were completed as outlined. Specific comments on each of these tests are contained in Section 6 of this report. Samples of the actual records kept during the test program are presented in Figures 1 through 21.

## 6. DISCUSSION OF TESTS AND INTERPRETATION OF DATA

### 6.1 Test Description

All Category II tests are identified by a number starting with J-200. To distinguish between tests at Hanscom Field and at Westover, all tests conducted at Westover AFB are identified by the suffix W. Since some tests were repeated at both stations, tests will be reported for each station (i.e., tests performed at Hanscom and tests performed at Westover).

### 6.2 Test Documentation

#### 6.2.1 Manpower Log (Fig. 1)

This log is a record of man hours expended during all test, modification, and maintenance efforts. The "REFERENCE" column shows the type of effort expended in addition to the technical order, request, or reference document number calling for this effort. This log also shows time required to perform maintenance analysis and the time for Set-Up and Tear Down of the equipment.

#### 6.2.2 Maintenance Log (Fig. 2)

This log is a record of all maintenance and modification efforts, and equipment down time. This log is organized to indicate an individual component record for the equipment, showing the date of maintenance or modification, the time the equipment went out of service, and the time the equipment was put back in service. The "REFERENCE" column will be noted with the technical order, request, or reference document number, or will indicate emergency as the case may be, in addition to the type of effort (i.e., test, maintenance, modification) that is required to maintain equipment performance.

#### 6.2.3 Daily Operational Log (Fig. 3)

This log indicates all efforts and observations not covered by the Manpower or Maintenance Logs. Entries in this log were recorded as events occurred and began with the completion of equipment installation.

### 6.3 Calibration Check (J-200)

The AN/TMQ-15, Wind Measuring Set, was calibrated in the UAC Research Laboratory Pilot Wind Tunnel on 27 September 1962 and 10 October 1962. Several runs were made on the equipment and the data acquisition included:

a. True Tunnel Speed versus AN/TMQ-15 Indicated Speed (see Figures 4, 5, and 6)

b. AN/TMQ-15 Speed Sensor RPM versus AN/TMQ-15 Indicated Speed (see Figure 7)

c. Response Time of AN/TMQ-15 Anemometer Cup Assembly (see Figure 9)

6.3.1 From examining the curves of Figures 4, 5, and 6 no radical departure from the true value of air speed is observed. Difficulty was experienced in reading the AN/TMQ-15 Wind Speed Indicator and the Eput count (item of test equipment) from the wind speed transducer above 65 knots. It was observed that the AN/TMQ-15 Wind Speed Indicator was fluctuating approximately ±2 knots; a similar phenomenon was also observed on the Eput meter. It was further noted that at 65 to 80 knots the anemometer cup assembly did not track smoothly in the horizontal plane. This is probably due to a slight dynamic unbalance in the anemometer cup assemblies which provided a wobbling of the shaft of the light chopper and, in turn, the production of unsteady pulses. This phenomenon explains the scatter in data shown in Fig. 8 at speeds above 65 knots.

6.3.2 The response time of the anemometer cup assembly and optical-electrical transducer was measured by inserting a Pulse Rate Integrator in the wind speed transmitter line and feeding the signal to an oscilloscope with the resultant trace recorded by a camera. See Fig. 8 for a curve of the response time characteristic. The response time of 0.27 seconds shown in Figure 9 is a conservative value of the aerodynamic response of the Anemometer Cup Assembly since slight error is introduced by the response of the Pulse Rate Integrator used to convert the pulses to an analog level.

## 6.4 Initial Inspection Hanscom Field (J-201)

### 6.4.1 Physical Inspection (J-100)

The set was delivered in two fibre glass carrying cases with no apparent damage.

### 6.4.2 Uncrating (J-101)

No directions for uncrating were available. The only unusual requirement noted in uncrating was that the handle portions of the latches were too small. Some could not be opened by hand and were opened by using a screwdriver as a lever.

### 6.4.3 Visual Inspection (J-102)

No packing list or equipment listing was provided. The only apparent damage was a chipped plastic cup in the center of the Wind Direction Indicator. This chip did not break the waterproof seal and would not cause any ill effects.

6.4.3.1 The following items were received:

| | | |
|---|---|---|
| a. | Carrying Case (Translator) | SN745 |
| b. | Carrying Case (Mast) | SN43 |
| c. | Translator-Power Supply | AFCRL Ident 250 |
| d. | Direction Sensor | B&W3 |
| e. | Speed Sensor | B&W785 |
| f. | Vane | SN406 |
| g. | Anemometer Cups | C23, 976, D59, D60 |
| h. | Two Spare Batteries | |
| i. | Mast | |
| j. | Three Guy Wire Assemblies | |
| k. | Three Stakes (Screw Type) | |
| l. | Cross Arm | |
| m. | Cable-Translator to Mast | |
| n. | Cable-AC input | |
| o. | Cable-External Battery | |
| p. | Cable-W.D. Recorder | |
| q. | Cable-W.S. Recorder | |
| r. | Three Allen wrenches, with Handles | |
| s. | Nut Driver | |
| t. | Screw Driver | |

## 6.5 <u>Equipment Setup</u> (J-202)

The AN/TMQ-15 sensors were installed using the cable supplied approximately twenty (20) feet from the AN/GMQ-11 sensors. The Operator's Manual instructions are adequate for setting up and calibrating the equipment with the following additions.

a. When the Mast sections are being extended the pins should be inserted and then the upper section should be pulled down slightly to be sure the pins are seated.

b. The Mast to Translator Cable should be coiled a few turns at both the Translator and Mast ends to help prevent any strain on the cable connectors if the cable is accidently snagged.

6.5.1 The Wind Direction Sensor was oriented to True North by shooting the sun with a theodolite and referencing the readings to the Air Almanac. A fixed reference point was established to allow the set to be taken down and set up again without having to use the theodolite each time. The only discrepancies that were noted during the equipment setup were as follows:

a. One snap hook was hard to put on the screw anchor. This was corrected by filing out the hook.

b. The "sight bar" on the Wind Direction Sensor is too wide (3/16 inch) to orient the sensor accurately.

c. The handles on the carrying case latches are very hard to open by hand.

### 6.6 Accuracy Check (J-203)

The AN/GMQ-11 used in this comparison test was calibrated by the Field Maintenance Shop, Detachment 37, 8th Weather Group. The AN/TMQ-15 was placed approximately 20 feet from the AN/GMQ-11 during data acquisition periods. Comparison readings were taken at 15 second intervals for 12 1/2 minute periods. The average error of 100 readings taken with the AN/TMQ-15 and compared with the AN/GMQ-11 was 3.81 degrees in azimuth, and 0.11 knots in speed. Figures 10 through 13 illustrate the data recorded during the comparison tests. The deviation of the readings of the two wind measuring sets can be explained as follows:

6.6.1 A slight error is introduced in the manual recording of data, because the parameters of wind speed and direction cannot be correlated exactly in time between the AN/GMQ-11 and the AN/TMQ-15.

6.6.2 The moment of inertia of the AN/TMQ-15 wind speed and direction sensors is less than that of the AN/GMQ-11. Under gusty wind conditions the devices under test will have a different aerodynamic response and damping coefficient; therefore a slight error would be introduced in attempting to take comparative readings.

6.6.3 Each device has slight calibration error in that they depart to some extent from indicating true wind speed and direction.

6.6.4 During the early phase of the comparison tests difficulties were experienced with the AN/TMQ-15 in the following areas.

6.6.4.1 It was observed that there was about 5 degrees of play between the wind vane and the synchro shaft. Test results on the static accuracy of the Wind Direction Vane as illustrated in Figure 14 shows an over-all average error of +0.2 degrees when the vane was rotated uniformly in the Clockwise (CW) and Counterclockwise (CCW) direction. The highest individual error of 66 readings was 3.5 degrees. When the vane was moved a few degrees beyond the desired point and brought back, the average error was 2.86 degrees, and the highest individual error was 6.5 degrees (see Fig. 15). The reason for the 5 degree play between the Wind Vane and the synchro shaft was that the Vane aligning slot is too large and/or the spring clip is too small. This was remedied by bending the spring clip to provide contact with both sides of the slot. With the correction made and a re-run of static accuracy data the following results were obtained.

a. When the vane was rotated uniformly the average error was 0.16 degrees and the highest error was 2.0 degrees (see Fig. 16).

b. When the vane was moved beyond the desired point and brought back the average error was 0.86 degrees and the maximum error was 3 degrees (see Fig. 17).

6.6.4.2 The AN/TMQ-15 400 Cycle Oscillator (Synchro Excitation) was generating ripple on the +12 volt power lead. The 12 volt power lead supplies the power in the light chopper in the wind speed sensor head. The ripple was amplified by the light chopper amplifier and sent back to the wind translator as a normal wind speed signal. The ripple was eliminated by decoupling the +12 volt power supply.

## 6.7 Tactical Capability (J-204)

The AN/TMQ-15 was disassembled at an average interval of 6 days, and transported over smooth, fair and poor roads and cross-country. The equipment was set up after each trip with little apparent physical damage to any part. In some cases, however, calibration was off slightly. During one instance it was noted that the wind speed indicator was not working. Investigation revealed that two leads were opened at the plug on the mast end of the translator-mast cable. Since this type failure could easily occur in the field due to people tripping over the cable, it is recommended that the cable be fastened to the mast and to the translator case by means of a spring type clamp.

## 6.8 Westover AFB

### 6.8.1 Initial Inspection (J-201W)

#### 6.8.1.1 Physical Inspection (J-100W)

The equipment was received from Hanscom Field via AF truck on 7 December 1962. The Air Relief Valve on the carrying case containing the mast assembly was bent. No other external damage to the cases was observed except minor abrasions on the carrying cases.

#### 6.8.1.2 Uncrating (J-101W)

No uncrating instructions or packing list were received with the equipment. The carrying case latches are extremely difficult to open by hand.

#### 6.8.1.3 Visual Inspection (J-102W)

a. All items listed in paragraph 6.4.3.1 were received at Westover.

b. The following discrepancies were noted when the equipment was unpacked:

1. Plastic cap on Wind Direction Indicator chipped.
2. Mast assembly was in very poor condition.
3. Spring clips on mast had rusted and lost elasticity.
4. Clips must be tied down with string in order to extend mast.
5. Legs of tripod were bent.

#### 6.8.1.4 Test Setup (J-202W)

During the test the following discrepancies were noted:

a. The AN/TMQ-15 was first installed in the vicinity of the METRO Building. The soil in this area is fairly level and consists mostly of sand. Considerable difficulty was encountered in the installation of the mast due to inability to secure the guy wire anchors firmly in the sandy soil. The tripod legs would sink in the ground placing the entire weight of the mast on the base plate. The bottom of the mast would tend to dig in as tension was applied to the guy wires which resulted in the cable connector at the base of the mast becoming filled with dirt. The Translator-Power Supply was operated from 115 volts, ac, base power for approximately two weeks. During this interval the Wind Direction Recorder Output Synchro-Potentiometer became inoperative due to failure of the spring coupling between the shaft of the synchro and the shaft of the potentiometer. This failure was first detected on 27 December 1962.

b. The mast assembly was dismantled on 28 December 1962 to permit testing of the synchro-potentiometer assembly. It was extremely difficult to remove the corkscrew type guy wire anchors from the frozen soil. It had also snowed during the interval that the AN/TMQ-15 was operating and the cable connector at the base of the mast had been covered with snow. The clips for attaching the guy wires to the mast and anchors had also collected moisture which had frozen, making removal extremely difficult.

c. The AN/TMQ-15 was re-installed in a new location in the vicinity of the METRO Building on 22 January 1963 with the Wind Direction Recorder output remaining inoperative. The mast assembly could not be erected utilizing the corkscrew type guy anchors as they could not be inserted in the frozen soil. It was necessary to fabricate three anchors from steel rod and eye-bolts in order to complete the installation.

d. On 4 February 1963 it was observed that the Wind Speed sensor was not rotating although winds as high as fifteen knots were being recorded by the AN/GMQ-11. The sensor was removed from the mast and upon examination it was found that moisture had collected in the sleeve surrounding the chopper shaft and had frozen the shaft to the sleeve. Average temperature for the previous eight hours was -10° F. The assembly was dried for approximately one hour with a stream of hot air. The sensor could not be disassembled and dried as one of the 4-40 Allen set screws securing the shaft was stripped and could not be removed without the possibility of damage to the shaft. The sensor was re-installed on the mast assembly and remained operational for approximately two hours when freezing recurred. The temperature was approximately 20° F at this time. The sensor remained inoperative overnight, but resumed normal operation the next morning when the temperature rose above 32° F.

e. The mast was disassembled on 6 February 1963 and the equipment installed near the AN/GMQ-11 on Runway 05. The facilities for orientation can only be accomplished with the mast collapsed and there is no provision for locking the mast sections so that rotation does not occur when the mast is extended to its normal operating position.

f. New batteries were installed just prior to the installation of the Wind Set and the equipment operated from the internal supply. The batteries are difficult to install in the Translator-Power Supply especially during the installation in the field. The exposed terminals of the batteries can be easily shorted to the case with the resultant reduction in life expectancy.

### 6.8.1.5 Accuracy Check (J-203W)

The AN/TMQ-15 was installed in the vicinity of the AN/GMQ-11 on Runway 05 at 1500, 6 February 1963. Installation problems are noted in the report for Test Number J-202W. The Wind Direction Recorder output was transmitted to the METRO Building via an existing telephone line between the AN/GMQ-11 and the METRO Building. The output was connected to a single-pen Esterline-Angus recorder operating at a chart speed of six inches per hour. The AN/GMQ-11 was connected to an RO-2 Wind Recorder operating at six inches per hour. Calibration of the Recorder output of the Translator-Power Supply requires that voice communication between the Translator-Power Supply and the Recorder be established. This requires an additional phone line or radio communication. The adjustment of the Wind Direction zero and full-scale controls is extremely critical and can easily be disturbed by vibrations encountered in the runway area.

### 6.8.1.6 Tactical Capability (J-204W)

Extreme difficulties were encountered in erecting and disassembling the equipment on frozen ground. These difficulties are documented in Test Setup (J-202W).

### 6.8.1.7 Power Supply Check (J-205W)

With 122 volts AC applied (nominal voltage in METRO Building) to the AN/TMQ-15, the dc output was 12 volts measured at point TR 12 P 5R. There are two voltages supplied from the internal battery supply; one which is nominally +12 volts and is connected to the chopper of the Speed Sensor and is supplied from a single SR-2817 battery and a second supply which is nominally +12 volts, regulated to +9 volts which supplies the power for the Translator. The former is identified as $E_1$ in the following table, and the latter as $E_2$.

TABLE I

Voltage vs. Time of Operation

| Date | Time of Measurement | $E_1$ Volts | $E_2$ Volts | Battery Test kts | Elapsed Time hours |
|---|---|---|---|---|---|
| 2-6-63 | 1500 | 13.25 | 13.25 | 40 | -- |
| 2-6-63 | 1630 | 13.25 | 13.20 | 40 | 1.5 |
| 2-7-63 | 0800 | 13.20 | 12.30 | 35 | 17.0 |
| 2-7-63 | 1630 | 13.00 | 12.25 | 36 | 25.5 |
| 2-8-63 | 1200 | 12.90 | 8.30 | 24 | 45.0 |
| 2-8-63 | 1630 | 12.60 | 8.40 | 25 | 49.5 |
| 2-11-63 | 0800 | 13.00 | 8.50 | 28 | 113.0 |

The recorder output was found to be unusable due to low output at 1200 on 8 February 1963. Variations in the voltage readings obtained are probably due to changes in temperature. Temperatures during this period of operation ranged from 10° F to 42° F. The battery check circuit only checks battery $E_2$, the power for the translator. The above table illustrates that the translator battery supply was useful for a period of 45 hours between the temperature range of 10° F to 42° F. The life of the batteries would be decreased at lower temperatures. Consideration should be given to substitution of standard batteries in place of the Mallory SR-2817 battery. The Mallory battery is a special order item, costing $42.00 per unit, with four units required. As indicated previously, limited life (45 hours) is obtained under low temperature conditions.

## 6.9 Reliability and Maintainability Analyses

### 6.9.1 General Discussion

The Category II Tests performed on the AN/TMQ-15, Tactical Wind Measuring Set, at the Hanscom and Westover 433L Test Installations, extended over the period 10 November 1962 to 15 February 1963. Based upon the performance and reliability data obtained and analyzed in the course of Category II testing, it has been concluded that the Wind Measuring Set represents a reasonable approach for tactical wind speed and wind direction equipment. However, the use of the Wind Measuring Set, as presently fabricated, is not recommended primarily because of its poor maintainability characteristics in the Translator-Power Supply Unit, and the poor quality of the mast which would not be able to withstand the expected tactical environment.

#### 6.9.1.1 Data Collection

The basic means for obtaining the reliability-maintainability data during the Category II tests of the AN/TMQ-15 was the WSC Operational Trouble and Maintenance (OT&M) Report (refer to Figure 18 for sample form). Other test records and reports as well as narrative progress reports maintained throughout the tests, provided supplementary data. Personnel interviews with test personnel, particularly in regard to maintainability, supplied further information.

#### 6.9.1.2 Definitions

The following reliability term definitions will assist in understanding subsequent reliability discussions:

a. Availability (A) - Availability is the percentage of total time (operating plus downtime), that an equipment is actually operable, or alternately, it is the probability that an equipment will be available for use at any given instant.

$$A = \frac{\bar{T}}{\bar{T} + \bar{T}_D}$$

where $\bar{T}$ = Mean-time-between-failures

$\bar{T}_D$ = Mean-downtime-between-failures

b. Downtime (D) - Downtime is defined as the number of calendar hours that the equipment is not available for use. It includes all active maintenance downtime, both preventive and corrective. Repair delay time is not considered.

c. Failure Rate (F) - Failure rate is defined for a particular interval as the average number of failures occurring per unit time in that interval. It is assumed that the failure rate is constant during the useful life of the equipment and, therefore, is equal to the reciprocal of the MTBF.

d. Mean-Downtime-Between-Failures ($\bar{T}_D$) - Mean-Downtime-Between-Failures is simply the mean or average of the downtime hours during periods between successive failures. $\bar{T}_D$ may be used as a quantitative expression for maintainability.

e. Mean-Time-Between-Failures ($\bar{T}$ or MTBF) - The MTBF for a particular equipment in a given time interval is the mean value of the operating periods between all failures occurring in that equipment during that interval. It is assumed that the MTBF will remain constant during the useful life of the equipment. The mean operating time between independent failures is used as an index of the reliability of the equipment.

f. Random Catastrophic Failure - An unpredictable, sudden change in the operating characteristics of material resulting in a complete lack of useful performance.

### 6.9.2 Mean-Time-Between-Failures

Before any test data was evaluated, a prediction of the MTBF was made for the AN/TMQ-15 using standard reliability estimating techniques and the best available reference material. The predicted MTBF was calculated to be approximately 3700 hours based upon the available technical information.

Prior to the start of Category II Tests, the AN/TMQ-15 was subjected to Category I Tests under GRD cognizance (Reference a, Cat. I Test Report). Since an electronic equipment generally exhibits a relatively constant failure rate over the useful life (after debugging and before wearout), the operation of the equipment during the time prior to Category II Tests should not have a detrimental effect on the reliability values derived from the test data.

In the course of testing at Hanscom and Westover, a total of 956.5 hours of reliable operation were accumulated on the AN/TMQ-15. Reference to the Operational Trouble and Maintenance (OT&M) Report Summary Sheet (Figure 18) shows that of the eighteen OT&M Reports received, no relevant (catastrophic) failures occurred in the course of testing. It must be noted that malfunctions caused by or due to human error and manufacturer's defects are not classified as catastrophic failures. Further details regarding the OT&M Reports submitted during the test period can be found in subsequent paragraphs.

Analysis of experimental data from the Category II Tests indicates the MTBF of the AN/TMQ-15 to be in excess of 956.5 hours, but due to the lack of sufficient operating time accumulated during Category II Tests, it is impossible to express this figure with any degree of confidence. Based on the predicted 3700 hours MTBF value and using a one-sided Chi Square Distribution, it can be shown that in order to demonstrate an MTBF of 3700 hours with 90% confidence, the necessary amount of test time would be approximately 8500 hours with a maximum of only one failure allowable during this period. This amount of test time would be impractical to demonstrate due to cost and time limitations inherent in the 433L Program. It is anticipated that if the equipment were re-engineered with the recommended improvements implemented as contained in this section, a high MTBF value could be realized. This is assuming that under normal operation a good preventive maintenance program will be followed.

6.9.2.1 Factors for Increasing Reliability

6.9.2.1.1 As shown by OT&M Reports #101 and #106, two incidents were reported in which defective synchros provided unsatisfactory operation. In the first case the synchro movement was unstable thus causing the wind direction indicator dial to fluctuate accordingly. This synchro was subsequently replaced, but the replacement synchro was also defective (bearings). It is, therefore, recommended that for increased operational reliability, tighter quality control requirements be imposed on vendors supplying the parts used in the AN/TMQ-15 as it is quite likely that inferior parts other than the synchros are contained in the equipment. It is also recommended that all parts utilized be military approved rather than commercial grade items. These changes could probably have a substantial effect on the equipment and function reliability.

6.9.2.1.2 The guying assembly provided for securing the mast is inadequate, especially in gusty winds. The top of the mast sways substantially, thus producing an error in readings. A double set of guy wires may be necessary if dependable operation is to be achieved.

6.9.2.1.3 It has been reported (see Figure 15) that the 0-1 ma recorder output synchro potentiometer assembly in its present configuration is a problem area. The synchro which is attached to the shaft of the potentiometer by a coil-spring coupling can, through improper alignment, produce insufficient torque output for proper operation. (One way to destroy alignment is by hitting the synchro with hand or tool.) A replacement of the synchro-pot assembly by a more rugged system is necessary if reliable operation is to be realized.

6.9.2.1.4 On three occasions during the Category II testing (reference OT&M #s 309, 310 and 317) the wind speed and wind direction sensors became inoperative. Examination of the sensors revealed that moisture had entered the sensors and consequently froze during periods of low temperatures. If reliable operation is to be achieved, it is imperative, therefore, that the sensors be examined for possible elimination of further occurrences of this type in the production model.

### 6.9.3 Maintainability

Another important factor considered in the evaluation of an equipment is the speed and ease with which the equipment can be returned to service once a failure occurs, and/or preventive maintenance can be performed. One way to measure this is in terms of mean-downtime-between failures ($\bar{T}_D$). Actual downtime data was, for the most part, insufficient for an accurate picture of what a maintenance man might realize in a tactical type environment. But, from the conclusions drawn from the maintainability review conducted at the Westover Test Site, it appears that the AN/TMQ-15, in particular the Translator-Power Supply Unit, is extremely difficult to maintain. The evaluation of the data confirmed many of the earlier maintainability problem areas noted in the Category I Test Report and the progress reports received from the Hanscom and Westover Test Sites. The following subparagraphs discuss the recommended improvements which should be incorporated in the production version.

#### 6.9.3.1 Factors for Increasing Maintainability

##### 6.9.3.1.1 Translator - Power Supply Unit

6.9.3.1.1.1 To eliminate the possibility of the equipment operator accidently misaligning the adjustment controls, provision for these controls to be located under an access door is necessary. The present screw type cap over two of the adjustment controls also results in longer adjustment time expended than would be required if located under a hinged access door.

6.9.3.1.1.2 It is recommended that the adjustment control potentiometers used to acquire zero and full scale readings be replaced so that a small movement of the control will not yield the present large scale movement of the display. Also, the potentiometers should be more stable and less susceptible to shock.

6.9.3.1.1.3 The battery access door should be enlarged and labeled with the nomenclature of the items accessible through it. Also, the access door should be hinged for better accessibility. Further, an instruction sheet should be attached to the inside of the top cover of the Translator-Power Supply Unit providing the operator with the proper procedures and frequency of performing battery and calibration.

6.9.3.1.1.4 All units and parts contained in the AN/TMQ-15 should be properly labeled with all identifying information. Also, the various parts do not contain sufficient electrical characteristics for proper identification. Potentiometers, switches, synchros, and other large components are among those deficient in this area.

6.9.3.1.1.5 For additional maintainability improvement, each terminal should be labeled with the same code symbol as the wire to be attached to it. The labeling on each terminal as well as for all the components contained in the equipment should be in view and not hidden by units or other parts. Since the equipment is of the tactical type, and subject to somewhat severe environmental conditions and hard usage, all labels should be etched or embossed, particularly in the case of the mast and tripod assembly.

6.9.3.1.1.6 Provision for coded wiring is necessary if downtime is to be decreased. At present it is very difficult to trace wiring through the harnesses.

6.9.3.1.1.7 In order to replace and/or use hand tools on many components of the Translator-Power Supply Unit it is necessary in many cases to remove more than the unit in need of repair and/or replacement. In other words, parts are mounted not in an orderly array on a "two-dimensional" surface but are "stacked" one on another. This is a serious maintainability problem which should be avoided to the greatest extent possible in the production version.

6.9.3.1.1.8 All parts which are mounted on terminal boards, etc., should be mounted on one surface with associated wiring on the other side.

6.9.3.1.1.9 The wind direction indicator synchro, as received from the manufacturer, has a small, approximately 3/32 inch diameter slotted shaft. For use in the wind direction indicator a threaded cap approximately 6/32 inch diameter is installed over the end of the shaft to allow the pointer to be securely attached. This cap must be press fitted onto the shaft, thereby requiring the use of special tools for replacement of this item. It is, therefore, recommended that replacement synchros for production units be ordered with this cap pre-assembled for ease in maintenance.

6.9.3.1.1.10 To expedite troubleshooting equipment malfunctions, it is necessary that test points be provided so that the necessary measurements can be made at critical functional stages. For example, at the power supply output, regulator output, chopper output, etc. These test points should be easily accessible, preferably clustered in one location and not impeded by other parts of the equipment. If possible, each test point should be labeled with the in-tolerance signal or tolerance limits which should be measured, along with the designation of the unit providing the signal to the test point.

6.9.3.1.1.11 The present Translator-Power Supply Unit contains many wires and harnesses which can be pinched, broken by the cover, or burned by a soldering iron. Re-packaging would be necessary to eliminate this problem.

6.9.3.1.1.12 For proper insertion of a plug into its receptacle, keying of plugs and receptacles should be provided. Each plug should also be coded to the receptacle to which it is to be attached. The distance separating the receptacles from one another should be made farther apart for ease in insertion or removal of connectors.

6.9.3.1.1.13 For ease in reading the wind speed and wind direction dials under bad lighting conditions provisions for edge-lighting are desirable. A separate switch should be provided so that the dials can be lighted only when necessary, particularly when the Translator-Power Supply Unit is battery operated.

6.9.3.1.2 Mast and Tripod Assembly

6.9.3.1.2.1 Presently the receptacle at the base of the mast is in danger of becoming submerged in mud or water or even becoming frozen in the ground in cold climates. To eliminate this problem the mast base should be raised so as to be above ground. Also, rather than having the wire which runs up the center of the mast coil up when the mast is lowered or uncoil when the mast is raised, a hole should be provided at the mast base such that the wire can be pulled through and coiled-up by hand. This type arrangement decreases the possibility of this tightly coiled wire breaking in the mast where it would be difficult to repair. Also, by leaving this cable and plug more flexible there is less chance of personnel tripping over the cable and breaking leads in the plug as has occurred during the test period (OT&M #105, and 108).

6.9.3.1.2.2 For ease in orienting the wind direction sensor in the North direction, provisions should be provided for pinning the mast sections prior to extending the mast. A compass would also be necessary for proper orientation. To be sure the mast section is horizontal a level should be provided as a part of the mast. For installation of the mast assembly on rough terrain the legs of the tripod should be made adjustable in length and much more rigid than on the present model. In the event the tripod legs must be set in muddy, sandy or swampy areas, flat plates should be provided for attachment to each of the legs for increased footing. If the ground should freeze these plates need not be retrieved.

6.9.3.1.2.3 The metal used to fabricate the mast assembly should be homogeneous throughout. The metal must be non-corrosive, non-brittle and rigid. On the present mast assembly the mast pin springs rusted badly and lost their holding ability. It is felt that a more reliable type clamping arrancement is necessary. It is also imperative that all screws on the mast be the same size and non-corrosive. The use of Allen head screws should be avoided.

6.9.3.1.2.4 The clamps provided for securing the guy wires to the mast and ground stakes are inadequate in that they tend to freeze up, especially after getting wet. The spiral type ground stakes are difficult to install especially in frozen or rocky ground and also will not hold in swampy or sandy soil. It is, therefore, recommended that a different type guying system be devised which can be used under any environmental conditions.

6.9.3.1.3 Cases

6.9.3.1.3.1 With reference to the air and watertight cases in which the AN/TMQ-15 is packaged for transportation, the following recommendations are presented:

a. The present fasteners which secure the lid to the case are extremely difficult to snap open without using a tool. A fastener with a handle for added leverage would be required or another type fastener used.

b. For ease in carrying the AN/TMQ-15 over rough terrain it may be necessary that the equipment be packaged so as to be contained in four small cases (present arrangement of 2 cases is extremely heavy). Each case should be made such that they are not top heavy when filled. The edges of the lid and case should be rounded to prevent injury to personnel.

c. To be sure no difficulty is encountered in opening the cases, a sign should be attached next to the valve located on the case side reading "Open Vent Before Opening Case". If a partial vacuum is created in the case it would become impossible to open without first opening the vent.

6.9.4 Availability (A)

Since an expression for the AN/TMQ-15 Availability cannot be stated utilizing measured MTBF and $T_D$ values, the following assumptions are presented in order that an approximate Availability figure can be derived.

1. The inherent Reliability of the AN/TMQ-15 is assumed to be approximately 3700 hours, based on the analysis performed and documented 5 October 1962.

2. Utilizing information contained in Reference (a), the time allotted for performance of preventive maintenance (Battery replacement and calibration checks) during a 3700 hours period would amount to approximately 54 hours.

3. Approximately 5 hours ($\bar{T}_D$) would be required to repair a malfunction depending on the nature of the failure.

| MTBF (Hours) | $\bar{T}_D$ (Hours) | A (%) |
|---|---|---|
| 3700 | 59 | 98.4 |

Depending on the equipment duty cycle, the $\bar{T}_D$ figure presented above may be pessimistic in that preventive maintenance routines may be performed during periods when wind information is not critical. Also, a re-engineered version of the equipment should result in a $\bar{T}_R$ less than the figure presented above in assumption 3.

## 6.10 Summary of Human Factor Tests on the Wind Measuring Set, AN/TMQ-15

Human-factor tests were conducted in accordance with Reference (b), and the results are tabulated in this section.

The tests indicate that the equipment is adequate for use, operation, and maintenance by the programmed personnel for daytime use; however, there is no in-line illumination on this device and this condition limits night-time use.

### 6.10.1 Test Objectives

The major objective of the HF tests was to determine whether the wind-measuring set could be adequately set up, used, operated, and maintained by programmed personnel as outlined in Reference (c).

The specific objectives were evaluations of operator performance levels as influenced by:

a. arrangement, size and shape of controls
b. adequacy of display indicators
c. applicability of operating procedures
d. applicability of maintenance procedures

### 6.10.2 Test Results

#### 6.10.2.1 Static Human Engineering (HE) Evaluation of Equipment (J-206)

A static HE evaluation of the TMQ-15 was performed. The equipment was found to conform to good HE standards except where noted below:

(a) The control position that indicates the equipment is using 110 Volt power is labelled "RECT 12v DC", and this label should be changed to one more meaningful to the operator such as "110 V".

(b) The large number and types of controls are unnecessary. There are eight different operating controls; these could be reduced to four of the rotary type.

(c) The wind-direction display reads in directional increments (e.g., north, south, east, west, etc.) and this is not compatible with operational requirements outlined in Reference (d) which calls for readings of wind direction to the nearest ten degrees. The display should be graduated in ten degree increments.

(d) The wind speed and direction transducer units are interchangeable on the crossarm; however, the cable lengths will only permit operation of the transducers in one arrangement. The transducers and the crossarm should be labelled so that the correct arrangement is always accomplished.

(e) The large carrying case cover, which holds the wire, can only be placed on the case in one way, so that the latches are aligned. Labels should be provided which ensure proper orientation.

(f) The rear panel connector-points are not adequately labelled. Each connector receptacle should be unambiguously labelled according to function.

(g) The handles of the large carrying-case are designed to fit flush with the case when disengaged. When engaged, they lift to a position perpendicular to the case. The weight of the case makes it impossible to lift in an inverted position because the handles pinch the fingers against the case. However, the case is difficult to carry in the proper orientation due to the weight distribution, and this constitutes a hazard to personnel. The carrying case weighs approximately 180 lbs., and the wire, which constitutes about 70% of the weight, is stored in the top of the case. Consequently, when the case is lifted, it twists out of the handler's grasp, and the case is either dropped or injures the handler's wrist. It is recommended that the equipment case be redesigned so that the wire is stored on the bottom, or that a separate case be provided for the wire.

(h) The larger carrying case weighs 180 lbs., and, as indicated in Reference (e), this is in excess of the maximum carrying weight of 90 lbs. recommended for two handlers.

(i) The indicator unit has no provision for illumination of either displays or controls, and for night operation, additional light sources will be required if built-in illumination is not provided.

### 6.10.3 Functional Review

#### 6.10.3.1 Initial Setup of the Wind Measuring Set (J-207)

The TMQ-15 was examined in an operational setting, and the procedures and time requirements for setup were analyzed. The average time for setup by two operators was 20.5 minutes which is satisfactory, the setup procedures are adequate; however, certain equipment design defects that required inefficient procedures were noted. With the incorporation of the recommended modifications, it is estimated that average setup time would decrease to about 10 minutes. Those design defects and recommended remedies are:

(a) The turnbuckles, clamps, and hooks were rusted after short usage in the field, and were difficult to adjust. Those components should be replaced by units constructed of rust-resistant material.

(b) It is difficult to collapse the mast completely because of excess wire. If forced, the wire is in danger of being severed. This can be remedied by either placing the wire on the external surface or providing a procedure for periodically retracting the wire as the mast is collapsed.

(c) Four different fastening tools are needed for equipment assembly: two different-sized Allen wrenches, a Phillips screwdriver, and a standard screwdriver. Because those tools all operate on fasteners, it would be advisable to re-engineer the equipment so that all fasteners can be attached with one standard tool.

(d) The cross-arm is difficult to attach and detach because the receptacle is too small. This should be remedied.

(e) The latches should operate more easily, or should be replaced by another type.

(f) When setting up the mast, it is difficult to align the keys, and, if an error in alignment is made, the entire mast must be disassembled. This could be remedied by grooving the mast sections so that insertion would only be possible one way.

(g) Once the North-South arrow is pointed north, there is no assurance that it will not deviate from this alignment when the mast is raised. This can be remedied by the modification recommended in (f) above, and by a method of stabilizing the mast, which would insure no rotation.

(h) When the ground is hard, the screw anchors used for guying the mast assembly cannot be inserted by hand. A crowbar or comparable tool should be provided.

(i) The receptacle for the indicator unit cable is placed too low on the mast, which causes difficulty in attachment. The receptacle should be placed higher.

### 6.10.3.2 Equipment Operating Procedures (J-208)

Equipment operating procedures were evaluated for their compliance to HE standards, and were found to be adequate except where noted below:

(a) The sequence of procedures is adequate. However, there is no provision for calibrating wind-direction readouts in the field. This could be remedied by a simple equipment modification. By attaching a compass to the mast, prior to raising, the wind vane could be sighted accurately on North, and the wind direction indicator checked and adjusted, if necessary.

(b) The wind-speed check is performed with the scale factor at 100 knots, and if the scale factor is left in the 25-knot position, the wind-speed indicator could be damaged. This situation could be remedied by replacing the wind-speed toggle switch with a third position on the scale factor switch labelled "TEST".

(c) The operator is able to read the indicators from a viewing distance of approximately six feet in conditions of bright ambient illumination, however, the equipment is not usable at night without special lighting.

#### 6.10.3.3 Equipment Maintenance Procedures (J-209)

The equipment and available procedures were examined for maintainability and were found to be adequate. However, information about maintenance procedures was incomplete and additional activities may show the procedures to be otherwise. Inadequate characteristics are noted below:

(a) Certain test points and components which should be maintained periodically are inaccessible.

(b) Battery removal required the disconnection of four screws. A simple latch attachment would be more advisable.

(c) All test points are not adequately labelled.

(d) In order to perform maintenance, the display/control panel must be lifted. This panel is held in place by cam-lock screws, one of which is unfastened by hand, and the remainder, by screwdriver. It is recommended that all cam-lock fasteners be operable by hand.

## 6.11 Training Requirements (J-210)

### 6.11.1 Operation

Programmed personnel have the proper skill level to perform the necessary operating tasks, and additional training is required for the following tasks:

(a) Setup sequence - If the proper sequence is not followed, mast alignment can be outside the directional margin-of-error, and wind direction readings are in error.

### 6.11.2 Maintenance

As pointed out in paragraph 6.10.3.3, complete information on maintenance requirements is unavailable; however, it was noted that programmed maintenance personnel would require additional training in the following areas:

(a) Selsyn maintenance and calibration for the wind-speed unit.

(b) Knowledge of transducer operation and calibration.

## APPENDIX A

### References


a. Category I Test Report, Wind Measuring Set, AN/TMQ-15

b. Report #E-15 Appendix J, Category I and II Test Plan for Wind Measuring Set, AN/TMQ-15, dated 8 August 1962

c. Preliminary PED and QQPRI Work Sheets for the 433L System, September 9, 1962

d. Proposed Format for Operational Surface Weather Observations, WSC M-29, January 1962

e. Human Engineering Criteria for Aircraft, Missile, and Space Systems, Ground Support Equipment, MIL-STD-803, November 1959

MANPOWER LOG

STATION: ____________________

EQUIPMENT: ______________________________ SHEET NO. ______

| DATE | TIME | MAN HOURS EXPENDED | REFERENCE | TASK SUMMARY | INITIALS |
|---|---|---|---|---|---|
| | | | | | |

Figure 1

MAINTENANCE LOG

LOCATION: ____________________

EQUIPMENT: ____________________

| COMPONENT | DATE | EQUIPMENT TIME OUT - IN | FAILURE REPORT NO. | TASK OR REFERENCE | SUMMARY AND REMARKS | INITIALS |
|---|---|---|---|---|---|---|
| | | | | | | |

Figure 2

DAILY OPERATIONAL LOG

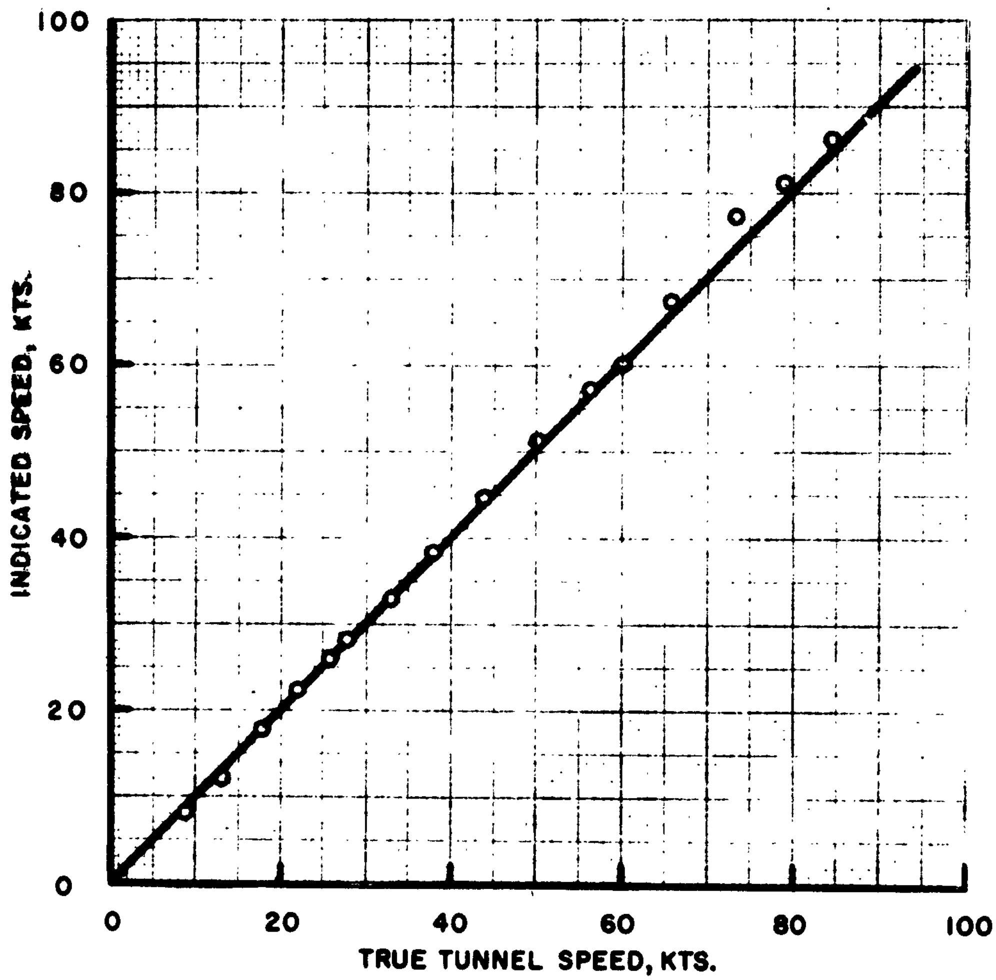
EQUIPMENT: ______________ SHEET NO. ______

LOCATION: ______________

| TEST NO. | RESULTS | DEVIATIONS OR MALFUNCTIONS AND DESCRIPTIONS | REMARKS | DATE | TIME | INITIAL |
|---|---|---|---|---|---|---|
| | | | | | | |

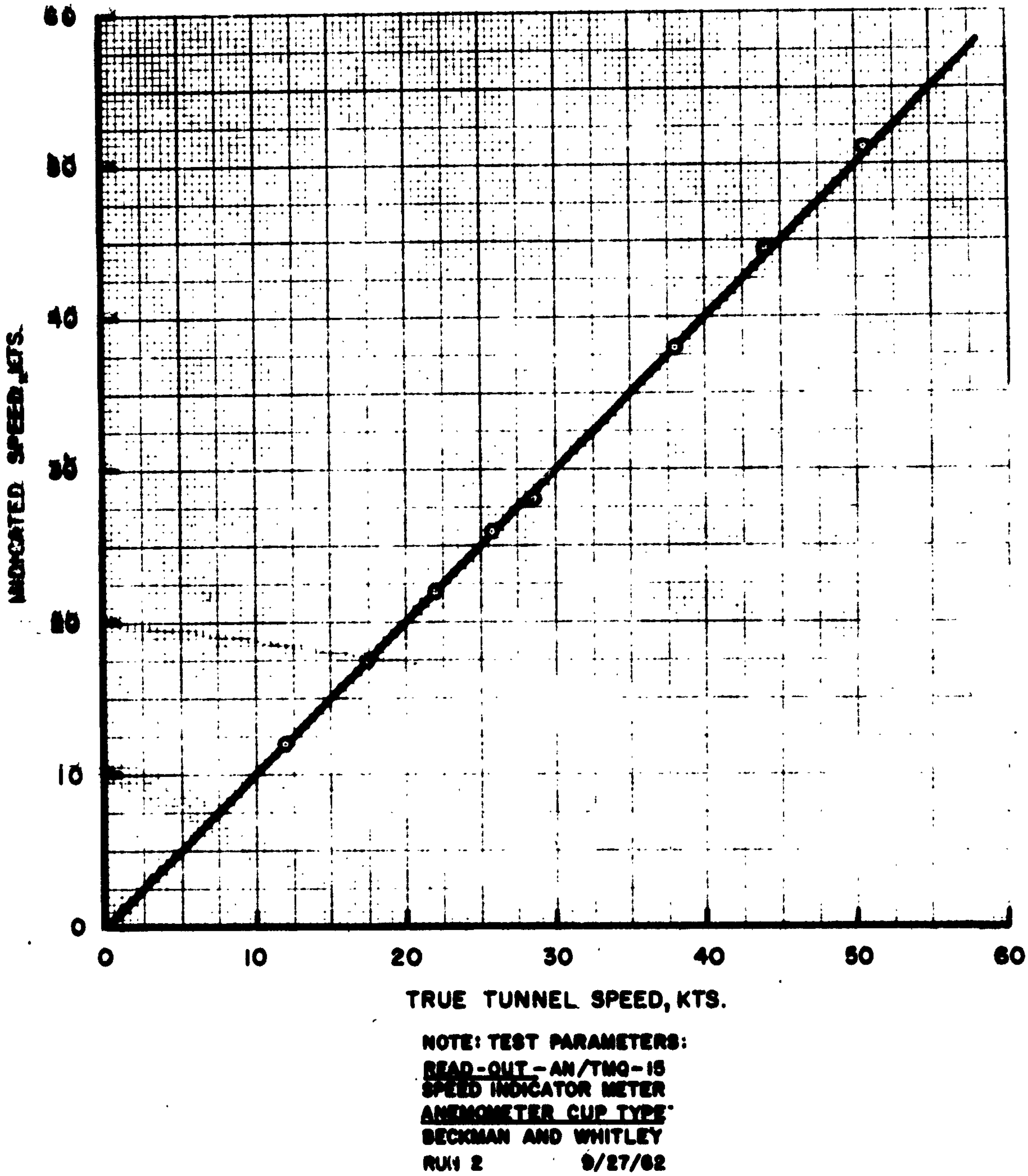
Figure 3

FIG. 4



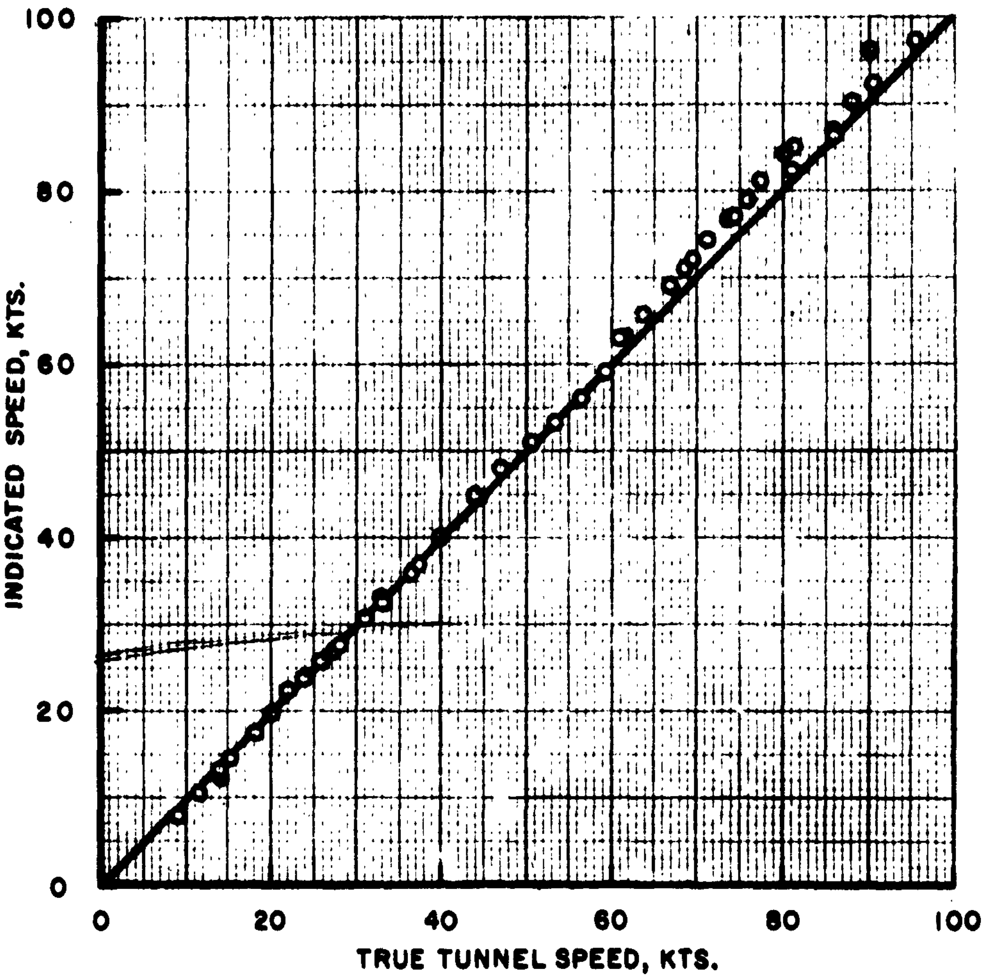

NOTE:
TEST PARAMETERS:
READ-OUT - AN/TMQ-15
SPEED INDICATOR METER
ANEMOMETER CUP TYPE -
BECKMAN AND WHITLEY
S/N 978
RUN 1 9/27/62

PLOT OF TRUE TUNNEL SPEED VS AN/TMQ-15 SPEED




PLOT OF TRUE TUNNEL SPEED VS AN/TMQ-15 SPEED

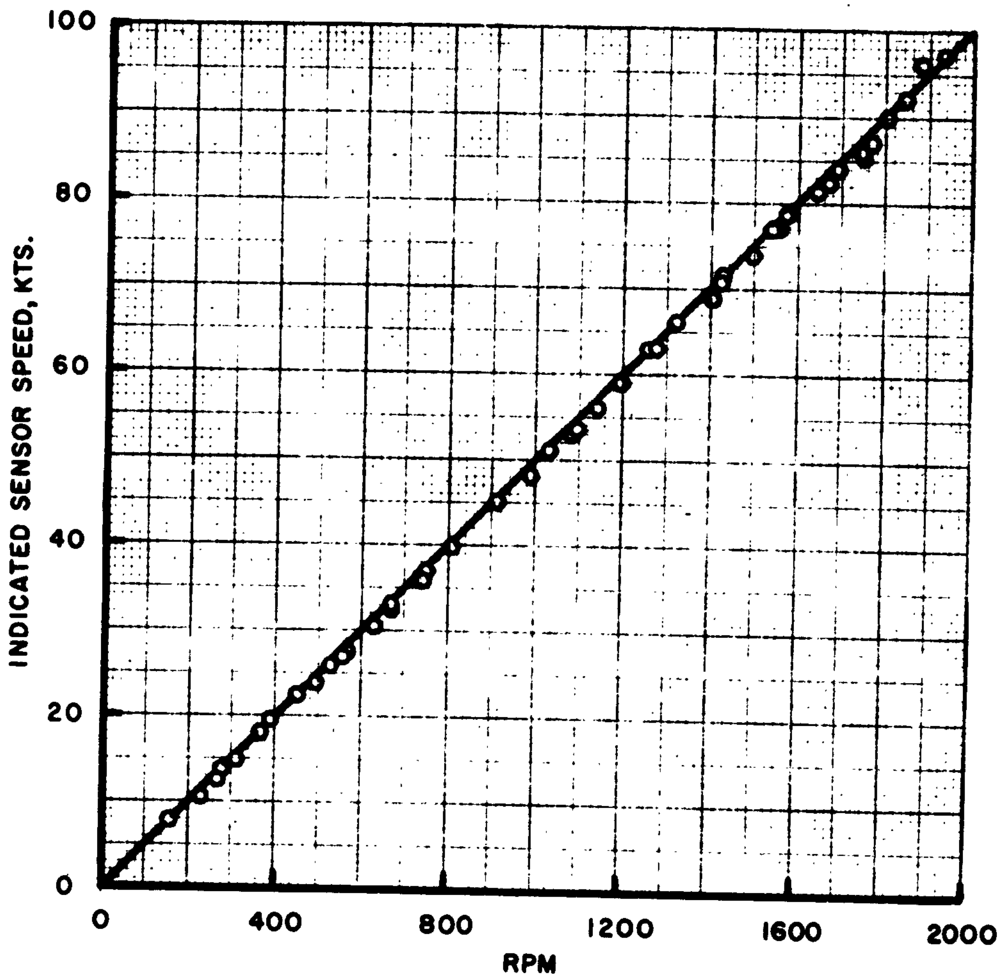
FIG. 6




NOTE:
TEST PARAMETERS:
READ-OUT - AN/TMQ-15
SPEED INDICATOR METER
ANEMOMETER CUP TYPE-
BECKMAN AND WHITLEY
D59
RUN 3 10/25/62

PLOT OF TRUE TUNNEL SPEED VS AN/TMQ-15 SPEED

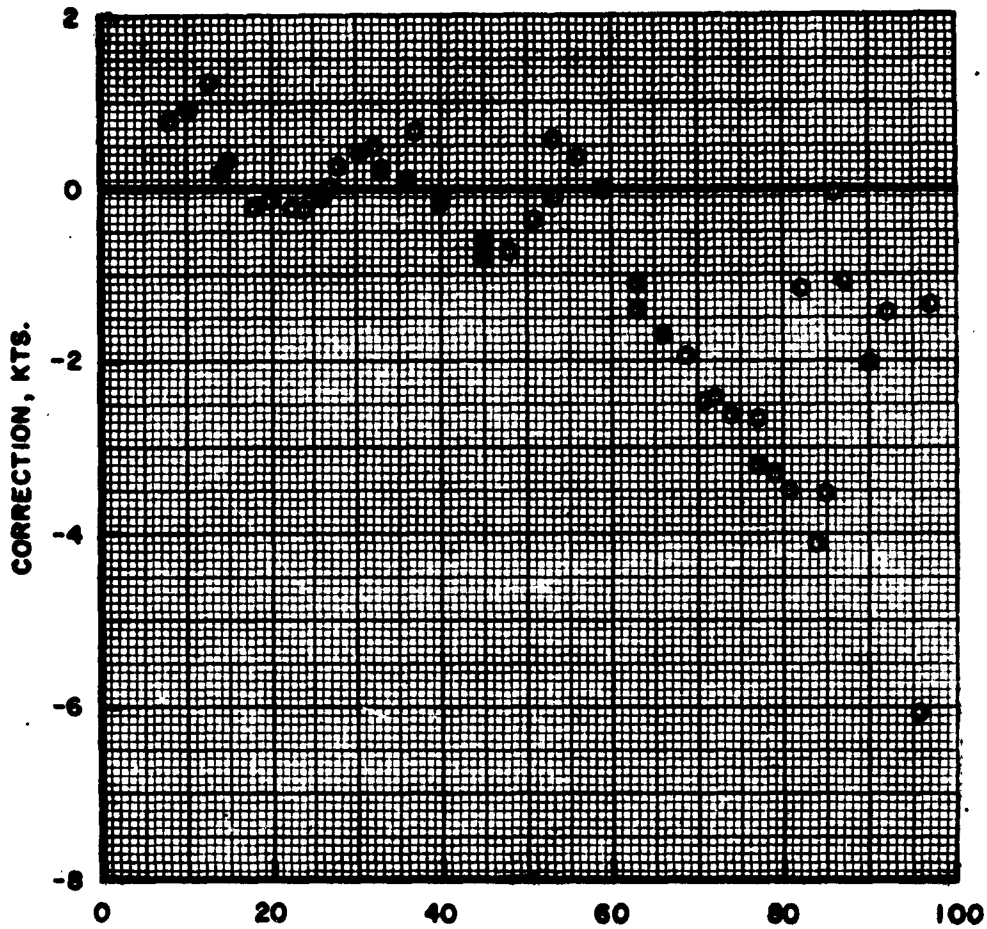
FIG. 7




NOTE:
TEST PARAMETERS:
READ-OUT - AN/TMQ-15
SPEED INDICATOR METER
ANEMOMETER CUP TYPE -
BECKMAN AND WHITLEY
D59
RUN 1 10/25/62

PLOT OF AN/TMQ-15 ANEMOMETER CUP RPM VS AN/TMQ-15 SPEED

FIG. 8

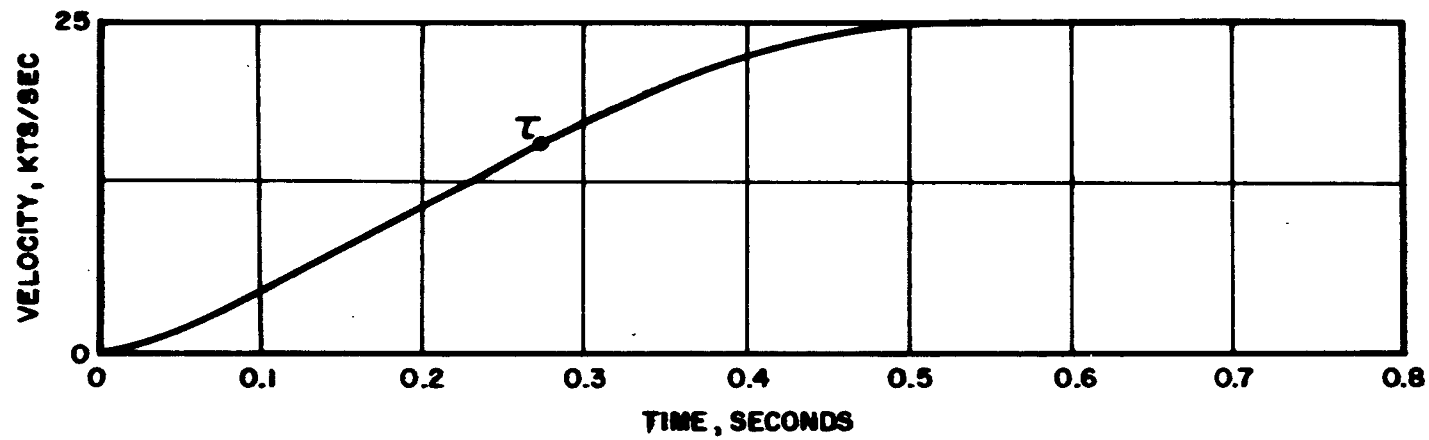



NOTE:
DATA TAKEN FROM FIG. 6
BECKMAN AND WHITLEY-
D99 CUP WITH PINS
AN/TMQ-15 RUN I
10/25/62

PLOT OF AN/TMQ-15 SPEED VS CORRECTION

FIG. 9

NOTE: $\tau = \frac{1}{e} = 62.5\%$, ONE TIME CONSTANT = 0.27 SEC.




**AN/TMQ-15 ANEMOMETER CUP ASSEMBLY RESPONSE TIME**

FIG. 10

DATE 4 December 1962

SHEET NO. 1

BATTERY NO. 37

TEMP. $40^{\circ}$ at start of test

| TIME EST | AN/GMQ-11 WIND DIR Degrees MN | WIND SPEED Knots | AN/TMQ-15 WIND DIR Degrees MN | WIND SPEED Knots | REMARKS |
|---|---|---|---|---|---|
| 1244.00 | 110 | 8.0 | 102 | 7.0 | |
| .15 | 090 | 8.0 | 090 | 7.0 | |
| .30 | 082 | 7.0 | 090 | 7.0 | |
| .45 | 073 | 6.0 | 078 | 6.0 | MN Magnetic North |
| 1245.00 | 083 | 6.0 | 090 | 8.0 | |
| .15 | 082 | 7.0 | 087 | 7.0 | |
| .30 | 085 | 7.0 | 090 | 8.5 | |
| .45 | 086 | 7.0 | 090 | 7.5 | |
| 1246.00 | 075 | 7.0 | 086 | 6.0 | |
| .15 | 083 | 6.0 | 087 | 5.5 | |
| .30 | 082 | 5.0 | 090 | 5.5 | |
| .45 | 084 | 5.0 | 093 | 5.0 | |
| 1247.00 | 086 | 5.0 | 075 | 5.5 | AN/GMQ-11 Average for Sheet |
| .15 | 075 | 4.0 | 081 | 5.0 | DIR $1991/_{25}$ - $79.64^{\circ}$ |
| .30 | 073 | 5.0 | 081 | 5.0 | SPD $1440/_{25}$ - 5.76 Knots |
| .45 | 074 | 5.0 | 083 | 5.5 | |
| 1248.00 | 076 | 4.0 | 078 | 5.0 | AN/TMQ-15 Average for Sheet |
| .15 | 076 | 5.5 | 090 | 5.5 | DIR $2196/_{25}$ - $87.84^{\circ}$ |
| .30 | 076 | 4.0 | 093 | 5.0 | SPD $1535/_{25}$ - 6.14 Knots |
| .45 | 089 | 4.5 | 105 | 5.0 | Deviation from AN/GMQ-11 for Sheet #1 |

COMPARISON TEST

FIG. 10 (cont'd)

DATE 4 December 1962

SHEET NO. 1

BATTERY NO. 37

TEMP. $40^{\circ}$ at start of test

| TIME | AN/GMQ-11 WIND DIR | WIND SPEED | AN/TMQ-15 WIND DIR | WIND SPEED | REMARKS |
|---|---|---|---|---|---|
| EST | Degrees MN | Knots | Degrees MN | Knots | |
| 1249.00 | 075 | 5.0 | 093 | 5.5 | |
| .15 | 080 | 6.0 | 096 | 8.5 | Wind Dir. $+8.2^{\circ}$ Wind Speed +0.38 knots |
| .30 | 063 | 6.0 | 090 | 6.0 | |
| .45 | 063 | 6.0 | 075 | 6.0 | |
| 1250.00 | 070 | 5.0 | 083 | 6.0 | |

COMPARISON TEST

FIG. 11

DATE 4 December 1962

SHEET NO. 2

BATTERY NO. 37

TEMP. 40° F at start of test

| TIME EST | AN/GMQ-11 WIND DIR Degrees MN | WIND SPEED Knots | AN/TMQ-15 WIND DIR Degrees MN | WIND SPEED Knots | REMARKS |
|---|---|---|---|---|---|
| 1250.15 | 093 | 5.0 | 078 | 4.0 | |
| .30 | 091 | 4.0 | 090 | 4.0 | MN Magnetic North |
| .45 | 093 | 6.0 | 090 | 5.0 | |
| 1251.00 | 093 | 5.5 | 096 | 5.5 | |
| .15 | 092 | 5.0 | 093 | 5.0 | |
| .30 | 095 | 4.0 | 105 | 4.5 | |
| .45 | 076 | 6.0 | 090 | 6.0 | |
| 1252.00 | 066 | 5.5 | 075 | 6.0 | |
| .15 | 073 | 6.0 | 090 | 6.5 | |
| .30 | 062 | 4.0 | 060 | 6.0 | |
| .45 | 069 | 6.5 | 081 | 6.5 | AN/GMQ-11 Average for Sheet |
| 1253.00 | 074 | 6.0 | 078 | 5.5 | DIR $1859/_{25}$ - 74.36° |
| .15 | 079 | 4.5 | 090 | 6.0 | SPD $1185/_{25}$ - 4.74 knots |
| .30 | 060 | 3.0 | 063 | 5.5 | |
| .45 | 060 | 4.5 | 063 | 4.5 | AN/TMQ-15 Average for Sheet |
| 1254.00 | 072 | 4.5 | 075 | 5.0 | DIR $1882.5/_{25}$ - 75.3° |
| .15 | 060 | 3.5 | 069 | 5.5 | SPD $1290/_{25}$ - 5.16 knots |
| .30 | 064 | 5.5 | 066 | 5.5 | |
| .45 | 066 | 3.5 | 066 | 4.5 | Deviation from AN/GMQ-11 for Sheet #2 |

COMPARISON TEST

FIG. 11 (cont'd)

DATE 4 December 1962

SHEET NO. 2

BATTERY NO. 37

TEMP. 40° F at start of test

| TIME | AN/GMQ-11 WIND DIR | WIND SPEED | AN/TMQ-15 WIND DIR | WIND SPEED | REMARKS |
|---|---|---|---|---|---|
| EST | Degrees MN | Knots | Degrees MN | Knots | |
| 1255.00 | 062 | 4.0 | 069 | 5.0 | |
| .15 | 068 | 3.5 | 075 | 4.5 | Wind Dir. +0.94° |
| .30 | 073 | 3.0 | 072 | 4.0 | Wind Speed +0.42 knots |
| .45 | 075 | 5.0 | 090 | 3.5 | |
| 1256.00 | 076 | 5.0 | 081 | 5.5 | |
| .15 | 067 | 5.5 | 072 | 5.5 | AN/TMQ-15 reading highest |

COMPARISON TEST

FIG. 12

DATE 5 December 1962

SHEET NO. 3

BATTERY NO. 37

TEMP. $42^{\circ}$ F at start of test

| TIME EST | AN/GMQ-11 WIND DIR Degrees MN | WIND SPEED Knots | AN/TMQ-15 WIND DIR Degrees MN | WIND SPEED Knots | REMARKS |
|---|---|---|---|---|---|
| 1300.00 | 062 | 17.0 | 075 | 17.0 | |
| .15 | 062 | 14.0 | 060 | 15.0 | MN Magnetic North |
| .30 | 060 | 16.0 | 075 | 16.0 | |
| .45 | 071 | 16.0 | 069 | 16.0 | |
| 1301.00 | 064 | 12.0 | 060 | 15.0 | |
| .15 | 064 | 16.0 | 075 | 14.0 | |
| .30 | 056 | 17.0 | 063 | 17.0 | |
| .45 | 051 | 13.0 | 060 | 15.5 | |
| 1302.00 | 052 | 14.0 | 042 | 11.0 | |
| .15 | 043 | 17.0 | 060 | 16.0 | |
| .30 | 069 | 17.0 | 078 | 16.5 | AN/GMQ-11 Average for Sheet |
| .45 | 045 | 11.0 | 051 | 15.0 | DIR $1423/_{25}$ - $56.92^{\circ}$ |
| 1303.00 | 060 | 13.0 | 066 | 12.5 | SPD $3785/_{25}$ - 15.14 knots |
| .15 | 035 | 12.0 | 036 | 16.5 | |
| .30 | 048 | 13.0 | 051 | 15.0 | AN/TMQ-15 Average for Sheet |
| .45 | 045 | 15.0 | 054 | 18.0 | DIR $1539/_{25}$ - $61.56^{\circ}$ |
| 1304.00 | 062 | 14.0 | 060 | 15.0 | SPD $3475/_{25}$ - 13.90 knots |
| .15 | 060 | 14.5 | 066 | 13.5 | |
| .30 | 056 | 16.0 | 063 | 15.0 | Deviations from AN/GMQ-11 for Sheet #3 |
| .45 | 053 | 13.0 | 048 | 11.0 | |

COMPARISON TEST

FIG. 12 (cont'd)

DATE 5 December 1962

SHEET NO. 3

BATTERY NO. 37

TEMP. 42° F at start of test

| TIME | AN/GMQ-11 WIND DIR | WIND SPEED | AN/TMQ-15 WIND DIR | WIND SPEED | REMARKS |
|---|---|---|---|---|---|
| EST | Degrees MN | Knots | Degrees MN | Knots | |
| 1305.00 | 054 | 12.0 | 054 | 10.0 | Wind Dir. +4.64° |
| .15 | 061 | 23.0 | 066 | 15.5 | Wind Speed - 1.24 knots |
| .30 | 060 | 17.0 | 063 | 16.5 | |
| .45 | 071 | 19.0 | 075 | 18.0 | |
| 1306.00 | 059 | 17.0 | 069 | 17.0 | |

COMPARISON TEST

FIG. 13

DATE 5 December 1962

SHEET NO. 4

BATTERY NO. 39

TEMP. $40^\circ$ F at start of test

| TIME | AN/GMQ-11 WIND DIR | WIND SPEED | AN/TMQ-15 WIND DIR | WIND SPEED | REMARKS |
|---|---|---|---|---|---|
| EST | Degrees MN | Knots | Degrees MN | Knots | |
| 1306.15 | 061 | 18.0 | 066 | 22.0 | |
| .30 | 065 | 24.0 | 075 | 24.0 | MN Magnetic North |
| .45 | 071 | 20.0 | 078 | 21.0 | |
| 1307.00 | 062 | 14.0 | 060 | 13.0 | |
| .15 | 044 | 12.0 | 045 | 15.0 | |
| .30 | 080 | 11.0 | 075 | 15.0 | |
| .45 | 072 | 13.0 | 063 | 12.0 | |
| 1308.00 | 068 | 16.0 | 066 | 11.0 | |
| .15 | 080 | 18.0 | 078 | 15.0 | |
| .30 | 073 | 21.0 | 081 | 23.0 | |
| .45 | 060 | 16.0 | 060 | 16.0 | AN/GMQ-11 Average for Sheet |
| 1309.00 | 058 | 10.5 | 060 | 10.0 | DIR $1533/_{25}$ - $61.32^\circ$ |
| .15 | 041 | 11.0 | 060 | 11.0 | SPD $3865/_{25}$ - 15.46 knots |
| .30 | 056 | 11.0 | 060 | 17.0 | |
| .45 | 053 | 12.0 | 060 | 14.0 | AN/TMQ-15 Average for Sheet |
| 1310.00 | 056 | 12.0 | 048 | 11.0 | DIR $1596/_{25}$ - $63.84^\circ$ |
| .15 | 059 | 11.0 | 060 | 17.0 | SPD $4085/_{25}$ - 16.34 knots |
| .30 | 059 | 18.0 | 066 | 20.0 | Deviation from AN/GMQ-11 for Sheet #4 |
| .45 | 064 | 17.0 | 063 | 18.0 | |

COMPARISON TEST

FIG. 13 (cont'd)

DATE 5 December 1962

SHEET NO. 4

BATTERY NO. 39

TEMP. 40° F at start of test

| TIME EST | AN/GMQ-11 WIND DIR Degrees MN | WIND SPEED Knots | AN/TMQ-15 WIND DIR Degrees MN | WIND SPEED Knots | REMARKS |
|---|---|---|---|---|---|
| 1311.00 | 053 | 17.0 | 060 | 17.0 | +2.52° +0.88 knots |
| .15 | 052 | 17.0 | 060 | 18.0 | Wind Direction +2.52° |
| .30 | 066 | 15.0 | 063 | 17.0 | Wind Speed +0.88 knots |
| 1312.00 | 070 | 21.0 | 075 | 17.5 | |
| .15 | 054 | 17.0 | 051 | 17.0 | |
| .30 | 056 | 14.0 | 063 | 17.0 | |

COMPARISON TEST

FIG. 14

Static Accuracy Test of Wind Direction Elements (Prior to Correction)
(Uniform Rotation)

| | CW | ERROR | CCW | ERROR | AVERAGE ERROR | CW | ERROR | CCW | ERROR | AVERA ERR |
|---|---|---|---|---|---|---|---|---|---|---|
| 360.0 | 000.0 | 0.0 | 000.0 | 0.0 | 0.00 | 360.0 | 0.0 | 002.0 | +2.0 | +1. |
| 22.5 | 21.5 | -1.0 | 21.0 | -1.5 | -1.25 | 21.0 | -1.5 | 23.0 | +0.5 | -0. |
| 45.0 | 45.0 | 0.0 | 45.0 | 0.0 | 0.00 | 43.0 | -2.0 | 46.0 | +1.0 | -0. |
| 67.5 | 68.0 | +0.5 | 68.0 | +0.5 | +0.50 | 67.5 | 0.0 | 67.0 | -0.5 | -0. |
| 90.0 | 92.0 | +2.0 | 92.0 | +2.0 | +2.00 | 89.0 | -1.0 | 92.0 | +2.0 | +0. |
| 112.5 | 114.0 | +1.5 | 113.0 | +0.5 | +1.00 | 113.0 | +0.5 | 115.0 | +2.5 | +1. |
| 135.0 | 135.0 | 0.0 | 136.0 | +1.0 | +0.50 | 135.0 | 0.0 | 137.0 | +2.0 | +1. |
| 157.5 | 156.0 | -1.5 | 159.0 | +1.5 | 0.00 | 157.0 | -0.5 | 157.0 | -0.5 | -0. |
| 180.0 | 180.0 | 0.0 | 181.0 | +1.0 | +0.50 | 179.0 | -1.0 | 180.0 | 0.0 | -0. |
| 202.5 | 202.0 | -0.5 | 201.0 | -1.5 | -1.00 | 203.0 | +0.5 | 201.0 | -1.5 | -0. |
| 225.0 | 225.0 | 0.0 | 224.0 | -1.0 | -0.50 | 225.0 | 0.0 | 225.0 | 0.0 | 0. |
| 247.5 | 246.0 | -1.5 | 247.0 | -0.5 | -1.00 | 247.0 | -0.5 | 248.0 | +0.5 | 0. |
| 270.0 | 269.0 | -1.0 | 270.0 | 0.0 | -0.50 | 270.0 | 0.0 | 270.0 | 0.0 | 0. |
| 292.5 | 292.5 | 0.0 | 292.5 | 0.0 | 0.00 | 292.0 | -0.5 | 291.0 | -1.5 | -0. |
| 315.0 | 317.0 | +2.0 | 315.0 | 0.0 | +1.00 | 315.0 | 0.0 | 317.0 | +2.0 | +1. |
| 337.5 | 338.0 | +0.5 | 337.0 | -0.5 | 0.00 | 337.0 | -0.5 | 341.0 | +3.5 | +1. |
| 360.0 | 360.0 | 0.0 | 002.0 | +2.0 | +1.00 | 361.0 | +1.0 | 361.0 | +1.0 | +1. |

Average Error $+0.2^{\circ}$

Max. Error $3.5^{\circ}$

Static Accuracy Test of Wind Direction Element (Prior to Correction)
(Overshooting)

| | CW | ERROR | CCW | ERROR | AVERAGE ERROR | CW | ERROR | CCW | ERROR | AVERAG ERROR |
|---|---|---|---|---|---|---|---|---|---|---|
| 360.0 | 357.0 | -3.0 | 356.0 | -4.0 | -2.5 | 357.0 | -3.0 | 357.0 | -3.0 | -3.00 |
| 22.5 | 19.0 | -3.5 | 17.0 | -5.5 | -4.0 | 018.0 | -4.5 | -17.0 | -5.5 | -5.00 |
| 45.0 | 42.0 | -3.0 | 39.0 | -6.0 | -4.5 | 040.0 | -5.0 | 043.0 | -2.0 | -4.00 |
| 67.5 | 65.0 | -2.5 | 65.0 | -2.5 | -2.5 | 066.0 | -1.5 | -68.0 | +0.5 | -0.50 |
| 90.0 | 88.0 | -2.0 | 088.0 | -2.0 | -2.0 | 087.0 | -3.0 | 089.0 | -1.0 | -2.00 |
| 112.5 | 112.0 | -5.0 | 112.0 | -5.0 | -0.5 | 112.0 | -5.0 | 112.0 | -5.0 | -0.25 |
| 135.0 | 135.0 | 00.0 | 132.0 | -3.0 | -1.5 | 132.0 | -3.0 | 133.0 | -2.0 | -2.50 |
| 157.5 | 153.0 | -4.5 | 153.0 | -4.5 | -4.5 | 153.0 | -4.5 | 152.0 | -5.5 | -5.00 |
| 180.0 | 177.0 | -3.0 | 175.0 | -5.0 | -4.0 | 174.0 | -6.0 | 175.0 | -5.0 | -5.50 |
| 202.5 | 198.0 | -4.5 | 198.0 | -4.5 | -4.5 | 197.0 | -5.5 | 201.0 | -1.5 | -3.50 |
| 225.0 | 219.0 | -6.0 | 223.0 | -2.0 | -4.0 | 219.0 | -6.0 | 222.0 | -3.0 | -4.50 |
| 247.5 | 247.0 | -5.0 | 244.0 | -3.5 | -2.0 | 243.0 | -4.5 | 246.0 | -1.5 | -2.75 |
| 270.0 | 265.0 | -5.0 | 268.0 | -2.0 | -3.5 | 265.0 | -5.0 | 266.0 | -4.0 | -4.50 |
| 292.5 | 289.0 | -3.5 | 291.0 | -1.5 | -2.5 | 290.0 | -2.5 | 290.0 | -2.5 | -2.50 |
| 315.0 | 310.0 | -5.0 | 314.0 | -1.0 | -3.0 | 311.0 | -4.0 | 314.0 | -1.0 | -2.50 |
| 337.5 | 331.0 | -6.5 | 334.0 | -3.5 | -5.0 | 334.0 | -2.5 | 336.0 | -1.5 | -2.50 |
| 360.0 | 357.0 | -3.0 | 357.0 | -3.0 | -3.0 | 357.0 | -3.0 | 358.0 | -2.0 | -2.50 |

NOTE: Coupling between Vane and Shaft has about 5° of play

Average Error 2.86°

Max. Error 6.5°

FIG. 16

Static Accuracy Test of Wind Direction Element (Corrected)
(Uniform Rotation)

| | CW | ERROR | CCW | ERROR | AVERAGE ERROR | CW | ERROR | CCW | ERROR | AVER ERR |
|---|---|---|---|---|---|---|---|---|---|---|
| 360.0 | 360.0 | 0.0 | 360 | 0.0 | 0.00 | 361 | +1.0 | 360 | 0.0 | +0. |
| 22.5 | 21.5 | -1.0 | 23 | +0.5 | -0.25 | 22 | -0.5 | 23 | +0.5 | 0. |
| 45.0 | 45.0 | 0.0 | 45 | 0.0 | 0.00 | 46 | +1.0 | 43 | -2.0 | -0. |
| 67.5 | 68.0 | +0.5 | 68 | +0.5 | +0.50 | 67 | -0.5 | 67 | -0.5 | -0. |
| 90.0 | 91.0 | +1.0 | 91 | +1.0 | +1.00 | 90 | 0.0 | 91 | +1.0 | +0. |
| 112.5 | 113.0 | +0.5 | 113 | +0.5 | +0.50 | 112 | -0.5 | 114 | +1.5 | +0. |
| 135.0 | 135.0 | 0.0 | 135 | 0.0 | 0.00 | 135 | 0.0 | 136 | +1.0 | +0. |
| 157.5 | 157.0 | -0.5 | 158 | +0.5 | 0.00 | 157 | -0.5 | 158 | +0.5 | 0. |
| 180.0 | 180.0 | 0.0 | 179 | -0.5 | -0.25 | 179 | -1.0 | 180 | 0.0 | -0. |
| 202.5 | 202.0 | -0.5 | 201 | -1.5 | -1.00 | 203 | +0.5 | 203 | +0.5 | +0. |
| 225.0 | 225.0 | 0.0 | 225 | 0.0 | 0.00 | 225 | 0.0 | 225 | 0.0 | 0. |
| 247.5 | 246.0 | -0.5 | 248 | +0.5 | 0.00 | 248 | +0.5 | 247 | -0.5 | 0. |
| 270.0 | 269.0 | -1.0 | 270 | -0.0 | -0.50 | 270 | 0.0 | 271 | +1.0 | +0. |
| 292.5 | 293.0 | +0.5 | 293 | +0.5 | +0.50 | 293 | 0.5 | 292 | -0.5 | 0. |
| 315.0 | 317.0 | +2.0 | 315 | 0.0 | +1.00 | 316 | +1.0 | 316 | +1.0 | +1. |
| 337.5 | 338.0 | +0.5 | 338 | +0.5 | +0.50 | 338 | +0.5 | 337 | -0.5 | 0. |
| 360.0 | 361 | +1.0 | 360 | +0.0 | +0.50 | 360 | 0.0 | 361 | +1.0 | +0. |

Average Error $+0.16^{\circ}$

Max. Error $1.5^{\circ}$

Wind Direction Static Accuracy Test (Corrected)
(Overshootings)

| | CW | ERROR | CCW | ERROR | AVERAGE ERROR | CW | ERROR | CCW | ERROR | AVERA ERRO |
|---|---|---|---|---|---|---|---|---|---|---|
| 360.0 | 360.0 | 0.0 | 362.5 | +2.5 | +1.25 | 361.0 | +1.0 | 362 | +2.0 | +1.5 |
| 22.5 | 22.5 | 0.0 | 24.0 | +1.5 | +0.75 | 22.5 | 0.0 | 25 | +2.5 | +1.2 |
| 45.0 | 45.0 | 0.0 | 48.0 | +3.0 | +1.50 | 45.0 | 0.0 | 47 | +2.0 | +1.0 |
| 67.5 | 67.5 | 0.0 | 69.0 | +1.5 | +0.75 | 67.5 | 0.0 | 68 | +0.5 | +0.2 |
| 90.0 | 90.0 | 0.0 | 90.0 | 0.0 | 0.00 | 90.0 | 0.0 | 93 | +3.0 | +1.5 |
| 112.5 | 112.5 | 0.0 | 114.0 | +1.5 | +0.75 | 112.5 | 0.0 | 114 | +1.5 | +0.7 |
| 135.0 | 135.0 | 0.0 | 135.0 | 0.0 | 0.00 | 135.0 | 0.0 | 135 | 0.0 | 0.0 |
| 157.5 | 157.5 | 0.0 | 157.5 | 0.0 | 0.00 | 159.0 | +1.5 | 158 | +0.5 | +1.0 |
| 180.0 | 179.0 | -1.0 | 180.0 | 0.0 | -0.50 | 182.0 | +2.0 | 180 | 0.0 | +1.0 |
| 202.5 | 202.5 | 0.0 | 202.5 | 0.0 | 0.00 | 203.0 | +0.5 | 204 | +1.5 | +1.0 |
| 225.0 | 225.0 | 0.0 | 225.0 | 0.0 | 0.00 | 225.0 | 0.0 | 225 | 0.0 | 0.0 |
| 247.5 | 247.5 | 0.0 | 249.0 | +1.5 | +0.75 | 247.5 | 0.0 | 248 | +0.5 | +0.2 |
| 270.0 | 270.0 | 0.0 | 273.0 | +3.0 | +1.50 | 270.0 | 0.0 | 272 | +2.0 | +1.0 |
| 292.5 | 292.5 | 0.0 | 292.0 | -0.5 | -0.25 | 291.0 | +1.0 | 295 | +2.5 | +0.5 |
| 315.0 | 315.0 | 0.0 | 316.0 | +1.0 | +0.50 | 315.0 | 0.0 | 318 | +3.0 | +1.5 |
| 337.5 | 339.0 | +1.5 | 339.0 | +1.5 | +1.50 | 339.0 | +1.5 | 339 | +1.5 | +1.5 |
| 360.0 | 360.0 | 0.0 | 360.0 | 0.0 | 0.00 | 361.0 | +1.0 | 363 | +3.0 | +2.0 |

Average Error $+0.84^{\circ}$

Max. Error $3.0^{\circ}$

## WSC OPERATIONAL TROUBLE AND MAINTEN

| EQUIPMENT / SYSTEM | | STATION |
|---|---|---|
| NOMENCLATURE | CODE # | NAME |
| WIND MEASURING SET, TACTICAL | 127 | WESTOVER AIR FORCE BA<br>HANSCOM AIR FORCE BA |

| | REPORT NO. | DATE NO. | DATE DAY | REPORT TYPE | WSC EQUIP LL, C OR W NO. | EQUIP LOW SUB DIV. S/N | TIME METER DES. | TIME METER READING | P.M. ROUT./ F.C. NO. | FIRST IND. | ISOL. TO | CAUSE | ACTION TAKEN | SYSTEM FUNCT. AFFECT. | DOWNTIME DAYS | DOWNTIME HRS & 10THS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HANSCOM | 101 | 11 | 8 | 3 | 127 | 250 | | | | | | | D | | | 43.0 |
| | 102 | 11 | 13 | 1 | 127 | 250 | | | | 3 | 1 | 9 | O | | | # |
| | 103 | 11 | 14 | 3 | 127 | 250 | | | | | | | A | | | 0.5 |
| | 104 | 11 | 14 | 5 | 127 | 250 | | | | | | | I | | | 2.5 |
| | 105 | 11 | 16 | 3 | 127 | 250 | | | | | | | D | | | 2.0 |
| | 106 | 11 | 23 | 1 | 127 | 250 | | | | 9 | 1 | 7 | D | | 3 | 4.0 |
| | 107 | 11 | 27 | 5 | 127 | 250 | | | | | | | E | | | 2.0 |
| | 108 | 11 | 30 | 3 | 127 | 250 | | | | | | | D | | | 18.5 |
| | 109 | 11 | 28 | | 127 | 250 | | | | | | | O | | | |
| WESTOVER | 311 | 12 | 27 | 1 | 127 | 250 | | | | 7 | 1 | 4 | A | | 39 | 23.5 |
| | 306 | 1 | 29 | 1 | 127 | 250 | | | | 6 | 3 | 0 | D | | | 22.0 |
| | 309 | 2 | 3 | 1 | 127 | 250 | | | | 6 | 1 | 4 | O | | | 14.5 |
| | 310 | 2 | 4 | 1 | 127 | 250 | | | | 6 | 1 | 4 | O | | | 17.0 |
| | 312 | 2 | 6 | 2 | 127 | 250 | | | | | | | A | | | 1.0 |
| | 314 | 2 | 6 | 7 | 127 | 250 | | | | | | | O | | | 2.0 |
| | 319 | 2 | 8 | 2 | 127 | 250 | | | | 7 | 1 | 4 | A | | 3 | 18.0 |
| | 317 | 2 | 12 | 1 | 127 | 250 | | | | 6 | 1 | 4 | O | | | 18.5 |
| | 318 | 2 | 14 | 1 | 127 | 250 | | | | 2 | 1 | 0 | E | | | 1.0 |

* DOWNTIME NOT KNOW - M

** NO MAINTENANCE TIME IN

DATE: 4 FEB. 1963
REVISED: 21 FEB. 1963

FIG. 18

# UBLE AND MAINTENANCE REPORT SUMMARY SHEET

| TATION | | | FROM | TO |
|---|---|---|---|---|
| AME | CODE | REPORT NOS. | 101 | 318 |
| TOVER AIR FORCE BASE | CEF | DATES | 11/8/62 | 2/14/63 |
| SCOM AIR FORCE BASE | BED | | | |

| | | | MAINTENANCE DATA | | | | | | REP'L, REPAIR AND ADJUST. DATA | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOL. TO | CAUSE | ACTION TAKEN | SYSTEM FUNCT. AFFECT. | DOWNTIME DAYS | DOWNTIME HRS & 10THS | REPAIR DELAY TIME DAYS | REPAIR DELAY TIME HRS & 10THS | MAINT. TIME MAN HRS & 10THS | PART REF, SYMBOL OR UNIT/MOD. NO. | SERIAL NOS. FAIL. ITEM | SERIAL NOS. REP'L | FEDERAL STOCK NO. | MANUF. | TYPE OF FAILURE | PRI/SEC FAILURE | REP'L AV LOCALLY | REP. BY | REMARKS |
| | | D | | | 43.0 | | 30.0 | 13.0 | WIND DIR. IND | | | DEFECTIVE SYNCHRO | KEA | 040 | P | N | 2 | Y |
| 1 | 9 | O | | | * | | | 0.5 | ANEMOMETER CUP | | | FAULTY ASSEMBLY | B&W | 945 | P | Y | 2 | Y |
| | | A | | | 0.5 | | 0.0 | 0.5 | LOCKING LEVER | | | CRYSTALIZED METAL | B&W | 070 | P | Y | 2 | Y |
| | | I | | | 2.5 | | 0.0 | 2.5 | POWER SUPPLY | | | 100µfd CAP TO GROUND | | | | | 2 | Y |
| | | D | | | 2.0 | | 0.0 | 2.0 | CABLE | | | HUMAN ERROR | B&W | 884 | P | N | 2 | Y |
| 1 | 7 | D | | 3 | 4.0 | 3 | 2.0 | 2.0 | WIND DIR. IND. | | | DEFECTIVE SYNCHRO | KEA | 040 | P | Y | 2 | Y |
| | | E | | | 2.0 | | 0.0 | 2.0 | WIND DIR. SENSOR | | | FAULTY ASSEMBLY | B&W | 225 | P | N | 2 | Y |
| | | D | | | 18.5 | | 17.0 | 1.5 | CABLE | | | HUMAN ERROR | B&W | 884 | P | N | 2 | Y |
| | | O | | | | | | | C23 CUPS | | | CUPS CRUSHED HUMAN ERROR | B&W | 070 | | | 2 | Y |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| 1 | 4 | A | | 39 | 23.5 | 39 | 22.0 | 1.5 | RECORDED OUT-PUT SYNCHRO (R-[illegible]) | | | DESIGN DEFECT | KEA | 226 | S | N | 2 | Y |
| 3 | O | D | | | 22.0 | | 21.0 | 1.0 | CABLE | | | CUT BY SNOW PLOW HUMAN ERROR | | | | | 2 | Y |
| 1 | 4 | O | | | 14.5 | | 13.5 | 1.0 | SPEED SENSOR | 785 | | DESIGN DEFECT | B&W | | P | N | 2 | Y |
| 1 | 4 | O | | | 17.0 | | 17.0 | 0.0** | SPEED SENSOR | 785 | | DESIGN DEFECT | B&W | | P | N | 2 | Y |
| | | A | | | 1.0 | | 0.0 | 1.0 | BATTERY | | | SR2817 | MAL | 130 | P | Y | 2 | Y |
| | | | | | | | | | | | | SR2817 P.M. | MAL | 130 | P | Y | | |
| | | | | | | | | | | | | SR2817 | MAL | 130 | P | Y | | |
| | | | | | | | | | | | | SR2817 | MAL | 130 | P | Y | | |
| | | O | | | 2.0 | | 0.0 | 2.0 | | | | MAINTENANCE TEST-RELOCATE EQUIPMENT | | | | | 2 | Y |
| 1 | 4 | A | | 3 | 18.0 | 3 | 16.5 | 1.5 | BATTERY | | | SR2817 | MAL | 130 | P | N | 2 | N |
| | | | | | | | | | BATTERY | | | SR2817 | MAL | 130 | P | N | | |
| | | | | | | | | | BATTERY | | | SR2817 P.M. | MAL | 130 | P | N | | |
| | | | | | | | | | BATTERY | | | SR2817 | MAL | 130 | P | N | | |
| | | | | | | | | | BATTERY | | | SR2817 | MAL | 130 | P | N | | |
| 1 | 4 | O | | | 18.5 | | 17.0 | 3.0 | SENSORS FROZE | | | DESIGN DEFECT | B&W | | P | N | 2 | Y |
| 1 | O | E | | | 1.0 | | 0.0 | 1.0 | W.S. RECORDER | | | CALIBRATION | B&W | | | | 2 | Y |

TIME NOT KNOW - MALFUNCTION OCCURED DURING NIGHT
NNTENANCE TIME INVOLVED - SENSOR LEFT TO THAW OUTSIDE